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Abstract

The Chinese Stock market had a special feature up to 2001 in that the stocks trading was segmented according to the type of investor (domestic and foreign). Since companies can issue both A shares (for domestic residents) and B shares (foreign investors) and the legal status of these shares are the same, they would be expected to have similar fundamental expected dividend flows. If discount rates are fixed this should imply that the share prices will be cointegrated. We test this proposition and find that there is no evidence for a long-run relationship for the time period under investigation. Then we show there are two structural breaks, corresponding to the regulatory shift in 2001 and the Asian financial crisis. After correcting for these structural breaks, we identify long run relationships and consider reasons for why such a relationship exists. By doing so we are able to throw some light on why there is a significant discount on B shares relative to the same share traded in the A market.

Key words: **Chinese stock market, Cointegration, Structure break, B share discount;**
JEL: **G15, G12**

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1 Introduction

The stock market in China has a special feature in the sense that it is divided according to the type of investor. Originally, the A share market is for domestic Chinese residents and is denominated in Chinese RMB Yuan, whereas the B share is for foreign investors, and denominated in US dollars. However in February 2001 domestic investors were allowed to trade in the B share market.

A company can issue A shares as well as B share and they have the same legal status. Of the approximately 1250 listed companies in the two exchanges, only 75 issued both A and B shares. A summary of key statistics relating to these two types of shares of Shanghai Stock Exchange (SSE thereafter) [1] is provided in Table 1.

Table 1
Some basic statistics of A and B share in SSE

	A share	B share
Number of Listed companies	821	54
Total number of shares issued	4602.18	100.17
Number of non-institutional Investor accounts	37.41	0.9986

** Data source: Shanghai Stock Exchange, www.sse.com.cn, 2005; Number of shares are in 100 millions, whereas number of investor accounts are in millions*

Since companies issuing B shares normally also issue A shares, they should have the same fundamental dividend flows and hence, assuming constant discount rates, they should be prices at similar levels. However, empirical evidence does not support this argument. A great deal of literatures has found that B share prices are persistently discounted relative to A share prices.

Bailey (1994) provided evidence of price discounts on B shares relative to A shares (see also Bergstrom and Tang (2001) for evidence on the size of the discount). The Chinese case is special and hence requires particular explanation, since in other countries the price discount is on the shares available to local residents (see Bailey et al. (1999)). Whilst there have been arguments based upon efficient market concepts there have also been suggestions that the explanation is due to rational speculative trading or more irrational type trading rules such as positive feedback.

Fernald and Rogers (2002) argue that the discount on B shares is due to the fact that there are few domestic financial assets available in China. Ma (1996) uses cross sectional method to study share prices data for 38 companies that have both A and B shares listed in two exchanges. He found that

[1] Shanghai Stock Exchange established in Dec. 19, 1990. It has 831 listed companies with total market capitalization around 2717 billions of RMB. Source: www.sse.com.cn

the differences between prices of A and B shares are correlated with investors' attitudes toward risk. He also considered that regulatory changes might explain the variability of B shares' discounts. Chui and Kwok (1998) found prior price movements affect prices changes in A and B markets and the direction of information flow is mainly from B share markets to A share markets. Sjoo and Zhang (2000) argue that this relationship holds only for Shanghai stock exchange. Groenewold et al. (2001) explored weak and semi-strong efficiency for both A and B shares traded on both exchanges for the period 1992-2001. They find evidence of departures from weak efficiency in the form of predictability or returns on the basis of their own past values, and also the predictability from A to B returns in Shanghai but no cross causality in Shenzhen.

Eun et al. (2001) use the lower risk aversion of Chinese investors to explain the premium prior to opening of the market. However Chen et al. (2001) use return variance of A and B stocks to proxy for risk but do not find any relationship between the A premium and this measure of risk. Eun et al. (2001) find that the B share discount is (positively) related to the covariance between the return on B shares and a world index and to the difference between global and Chinese risk-free interest rates. However they do not find it negatively related to the covariance between A share returns and the Chinese stock index, a result supported by Fernald and Rogers (2002), who also find no relations between the discount and the covariance identified by Eun et al. Chen et al. (2001) propose a liquidity-based explanation and find that stocks with the greatest differential in trading volume and turnover across the A and B market also have the greatest premium of the price on the A market. Hence the price premium on A shares represent higher trading costs in the B market.

A further idea is that domestic investors have more information than foreign investors. Choe et al. (2001) consider the case of Korea and find that this may apply to individual local investors but not local institutional investors. Applying this idea to the Chinese market it is clear that the B discount may reflect such informational asymmetry since trading in the A market is dominated by individual investors. Foreign investors with less information are unwilling to pay the price for stocks which Chinese investors pay (see Chakravarty et al. (1998). Chan et al. (2006) use spreads to determine the information asymmetry and find that the adverse selection component is higher for A shares and that the it becomes more significant for B shares after 2001. Chen et al. (2004) argue that whilst the removal of the control in 2001 has negated the impact of information asymmetry there still are significant discounts on B shares. Whilst they can explain some of the discount with reference to risk and liquidity they propose that behavioural factors (such as overconfidence) are also important.

Mei et al. (2005) argue that speculation in the A market is responsible for the A-share premium. They link trading volume to overvaluation in the presence of limited arbitrage (short-sales constraints which certainly operate in the Chinese markets). The key is that given the lack of arbitrage, sales will be prompted by over-optimistic traders. In a dynamic context this implies that individuals will buy a stock because they believe they will be able to sell to someone who values the asset more highly in the future. As a consequence there is a deviation between the price and fundamental value of the share. Furthermore as traders perceptions of future value are more dispersed the overvaluation gets worse and there is more trading. Karolyi and Li (2003) also find evidence to support the view that the share price difference represents non-risk effects. Specifically they examine the response of the price difference to the regulatory change in 2001 (which we also consider) and find that the response of share prices to this effect varies. Specifically small capitalization stocks (note that Chen et al. (2001) observe that asymmetric information problems will be less significant for large firms) and those with momentum appear to be most affected with the price differential falling substantially. Therefore they do not find differential risk exposure, trading volume or liquidity to be important. They interpret their results as confirming asymmetric information as being a key driver of the discount (in that after 2001 local investors with information could enter the market). They argue that momentum stocks are often riskier so the increase in price of such stocks in the B market could be down to risk preferences of local investors.

This paper is not about the B share discount itself. It approaches the issue from a different perspective which looks at whether there are long-run relationships between the two share markets - in other words is the discount predictable. We use cointegration to investigate this issue and do not find evidence for this. We also consider the possibility of structural changes in this relationship (as in Ma (1996)). Using the technique of Gregory and Hansen (1996) and Bai and Perron (1998), we find two breaks over the period of our data. Apart from the regulatory changes (see Ma (1996) for early discussion of the effect of regulation on the Chinese stock market) the Asian financial crisis seems to have played an important role in affecting A and B share relationship. Furthermore we propose various explanations for our results, consistent with earlier literature on the B share discount.

The organization of this paper is the follows: section 2 provides some analysis of why the share prices may be cointegrated and section 3 discusses the empirical techniques used; section 4 shows how we construct indices and statistical features of our dataset; section 5 outlines results of the empirical analysis; section 6 discusses the results and concludes.

2 Modelling the share prices in A and B markets

We start with the basic idea that the two types of share issued by Chinese companies should be valued according to the same underlying expected dividend flow. This assumes that information asymmetry (in the long-run) is not a major issue. It is not difficult to conjecture that whilst domestic investors receive information more quickly it is hard to suppose that information diffusion does not take place over time. Hence we do not rule out the information asymmetry (and consequent adverse selection) as an explanation for the B share discount.

Under constant discount rates it is straightforward to demonstrate (ruling out bubble solutions) that the price of a share is the discounted value of its expected dividend stream into the infinite future.

$$P_t = \sum_{i=1}^{\infty} \delta^i E_t D_{t+i} \tag{1}$$

where P_t is the price of the share, δ is the discount rate, $E_t(\cdot)$ is the expectation operator conditional on information at time t and D_{t+i} is the dividend paid at time $t+i$. Constructing an index of such shares we obtain

$$P_t^I = \sum_{j=1}^{N} \alpha_j \sum_{i=1}^{\infty} \delta^i E_t D_{t+i} \tag{2}$$

where $j = 1, ..., N$ is the index for shares and α_j is the weight given to the share j. Applying this formula to both A and B shares and assuming that discount rates are δ_A and δ_B and information in the two markets generate expectations E_t^A and E_t^B in A and B markets respectively then:

$$P_t^A = P_t^B + \sum_{j=1}^{N} \alpha_j \sum_{i=1}^{\infty} \left[\delta_A^i E_t^A D_{t+i} - \delta_B^i E_t^B D_{t+i} \right] \tag{3}$$

Note that the B share discount can be the result of differences in the discount rates (including the risk premium) or expectations, factors which have been used by previous literature to explain the observation.

We can observe that the price indices in the two markets are cointegrated if the discount rates and informational asymmetries are related in a constant manner over time. Hence we can write

$$P_t^A = a_0 + a_1 P_t^B + \eta_t \tag{4}$$

and a_0 accounts for the different discount rates and expectations and a_1 controls for different base-dates for indices and for the possibility that the discount on B shares is related predictably to the level of the index. The random error η_t has the usual properties and represents measurement errors in expected dividends in the two markets.

However there are major changes which have affected discount rates and expectations in the two markets. Firstly we would expect the Asian Financial Crisis to have increased the risk premium for international investors to invest in Asian (including Chinese) shares. Furthermore the events associated with this crisis will have become part of the information set which investors use to assess the fundamentals of shares. Similarly the change in regulation in 2001 which allowed domestic investors access to the B share market may well have influenced the relationship between the two indices.

As an alternative to this fundamental explanation we can also provide one more rooted in the behavioural finance tradition. Our basic model is that developed by DeLong et al. (1990) to which we refer as DSSW from now on. Their model has an overlapping generations structure. However we prefer to think of it as describing investors who use 'narrow framing'. As discussed in Barberis and Thaler (2005), the idea behind 'narrow framing' is that individuals may only think about certain aspects of the problem (referred to as 'mental accounting') when making a decision. Thus for an investment decision individuals may look at short-run returns rather than view asset holding in the long term. They may ignore aspects of the decision, focusing only on the returns to the investment portfolio rather than including other important aspects such as their labour income. Hence the structure proposed by DSSW, where individuals only trade twice, selling once and buying once, can be viewed as that investors plan over one time period only. Arbitrage is not feasible since rational agents (professional fund managers) must adopt a similar short-term time horizon to maintain their investor base. In reality arbitrage the inability to short-sell severely limits arbitrage possibilities in the Chinese case.

The DSSW model assumes that individuals maximize an utility function which is exponential in wealth, $U(w) = -e^{-\gamma w}$. We have two assets, a safe asset yielding return R and a risky asset. There are two types of trader, smart traders who know the true return on both assets is R, and noise traders who make mistakes predicting returns such that they predict the return to the risky asset as $R + \delta$ where δ is normally distributed with mean value δ^* and variance σ^2. DSSW show under these assumptions and with the trading structure described above that the prices of the risky asset (assuming the price of the safe asset is normalized to one) is given by:

$$P_t = 1 + \frac{\theta(\delta_t - \delta^*)}{1+R} + \frac{\theta\delta^*}{R} - \frac{2\gamma\theta\sigma^2}{R(1+R)^2} \tag{5}$$

If we consider the risky asset as the share indices we have constructed then we can apply 5 to these indices for the A and B market (P_t^A and P_t^B, respectively). Since we do not impose the same value for the indices we need to allow for different values for the case of no noise trading, which represented by constants α and β for A index and B index respectively. Proportion of noise traders are measured by the coefficient θ. Thus we have:

$$P_t^A = \alpha + \frac{\theta_A(\delta_t^A - \delta_A^*)}{1+R} + \frac{\theta_A \delta_A^*}{R} - \frac{2\gamma\theta_A\sigma_A^2}{R(1+R)^2} \tag{6}$$

$$P_t^B = \beta + \frac{\theta_B(\delta_t^B - \delta_B^*)}{1+R} + \frac{\theta_B \delta_B^*}{R} - \frac{2\gamma\theta_B\sigma_B^2}{R(1+R)^2} \tag{7}$$

Transforming 7 we can obtain:

$$\frac{\alpha}{\beta} P_t^B = \alpha + \frac{\alpha}{\beta}\left[\frac{\theta_B(\delta_t^B - \delta_B^*)}{1+R} + \frac{\theta_B \delta_B^*}{R} - \frac{2\gamma\theta_B\sigma_B^2}{R(1+R)^2}\right] \tag{8}$$

Using equation 6 and 8 we can see that:

$$\begin{aligned} P_t^A = & \frac{\alpha}{\beta} P_t^B - \frac{\alpha}{\beta}\left[\frac{\theta_B(\delta_t^B - \delta_B^*)}{1+R} + \frac{\theta_B \delta_B^*}{R} - \frac{2\gamma\theta_B\sigma_B^2}{R(1+R)^2}\right] \\ & + \frac{\theta_A(\delta_t^A - \delta_A^*)}{1+R} + \frac{\theta_A \delta_A^*}{R} - \frac{2\gamma\theta_A\sigma_A^2}{R(1+R)^2} \end{aligned}$$

and since $(\delta_t^B - \delta_B^*)$ and $(\delta_t^A - \delta_A^*)$ are random errors, we may write the equation above as:

$$P_t^A = a_1 P_t^B + a_2 + \epsilon_t \tag{9}$$

where $a_1 = \frac{\alpha}{\beta}$ represents the B share discount and $a_2 = -\frac{\alpha}{\beta}\left[\frac{\theta_B \delta_B^*}{R} - \frac{2\gamma\theta_B\sigma_B^2}{R(1+R)^2}\right] + \frac{\theta_A \delta_A^*}{R} - \frac{2\gamma\theta_A\sigma_A^2}{R(1+R)^2}$ is the level parameter.

We can therefore see that structural breaks (shift in the levels parameter) in the long-run relation between the two share indices will occur for a number of reasons:

- Changes in the proportion of noise traders in each market (θ_A, θ_B);
- Changes in the noise trader expectation in either market (δ_A^*, δ_B^*);
- Changes in the precision of noise traders estimates (σ_A^2, σ_B^2)

- Changes in the return on the risky asset R given differences in noise trader expectations, precision of the estimates, or in the proportion of noise trader across the two markets;

and, although we have not specifically listed this, if risk aversion parameters γ change differently for traders in the two markets then we would also find a shift in the cointegrating relationship.

We have identified two candidate events which can explain the changes in the long-run relationship. The first is the Asian financial crisis. We would argue that this may well have influenced δ_B^* for noise traders in the B share market, potentially changed the proportion of noise traders, increased the dispersion of noise trader estimates of return, and even influenced the excepted (required) return on B shares relative to A shares (international investors will demand a higher risk premium than domestic investors). For the second event (dismantling of legal restrictions on domestic investors investing in B shares) this should not have affected expectations of noise traders but may well have caused the proportion of noise traders in the B share market to increase as less sophisticated domestic investors now enter the B market.

We therefore find that the noise trader model can provide a framework to explain why two share indices constructed on the same shares may not behave the same in the long-run. We can also provide specific reasons for why we see changes in the relationship but it is difficult to make a clear inference of the causes for structural breaks for the case we are considering.

Hence, under either model of the A and B stock market we will want to investigate not only cointegration across the two markets but also the existence of structural breaks. We now turn to consider the methodology we use to investigate this latter issue.

3 Empirical methodology

3.1 Residual based cointegration test with structural break

Gregory and Hansen (1996) considered the testing of cointegration while allowing for possible structural breaks. Their method is a residual based technique. They suggest three models: level shifts, level and trend shifts and regime shifts. The statistics are designed to test the null of no cointegration against the alternative of cointegration in the presence of a possible regime shift. The shift point is assumed to be unknown and will be tested in the model.

Gregory and Hansen (1996) use three statistics ADF^*, Z_α^* and Z_t^* * to test for stationarity of OLS residuals of a possible cointegrated system. For the ADF test, we follow the procedure suggested by Campbell and Perron (1991), to start from a large lag and test down form this. If the coefficient of the last included lag is significant at 10% level, then we select it as this lag length; otherwise we reduce the order by one. We continue this procedure until the coefficient of the last included lag is significant. We calculate all ADF statistics for every possible breaking point within the test period and the construct the statistic:

$$ADF^* = \inf ADF(\tau) \tag{10}$$

$$Z_\alpha^* = \inf Z_\alpha(\tau) \tag{11}$$

$$Z_t^* = \inf Z_t(\tau) \tag{12}$$

Gregory and Hansen provide relevant critical values for these test statistics in the different models:

Model I, Standard cointegration

$$y_t = \mu_1 + \alpha_1 x_t + \epsilon_t \tag{13}$$

Model II. Cointegration with level shift (CC)

$$y_t = \mu_1 + \mu_2 DB_t + \alpha_1 x_t + \epsilon_t \tag{14}$$

Model III. Cointegration with level shift and trend (CT)

$$y_t = \mu_1 + \mu_2 DB_t + \alpha_1 x_t + +\beta_t + \epsilon_t \tag{15}$$

Model IV. Cointegration with regime shift (CS)

$$y_t = \mu_1 + \mu_2 DB_t + \alpha_1 x_t + \alpha_2 x_t DB_t + \epsilon_t \tag{16}$$

where the definition of dummy variable DB is that $DB_t = 1$ if $t > T_b$ and zero otherwise. T_b is the breaking point.

3.2 Test for multiple breaks

Bai and Perron (1998) and Bai and Perron (2003) consider both theoretical implications and empirical applications of multiple structural breaks in linear models. The existence of multiple structural breaks is attractive especially in long run time series analysis where different factors might affect the behaviour over the data period. Bai and Perron's method is applicable under a general framework of partial structural changes, which allows a subset of the parameters not to change. It can be expressed in compact matrix form:

$$\mathbf{Y} = \mathbf{X}\beta + \overline{\mathbf{Z}}\delta + \mathbf{U} \tag{17}$$

where $\mathbf{Y} = (y_1, y_2, ..., y_t)', \mathbf{X} = (x_1, x_2, ..., x_t)', \mathbf{U} = (u_1, u_2, ..., u_t)'$, $\delta = (\delta_1, ...\delta_{m+1})'$, and $\overline{\mathbf{Z}}$ is the matrix the matrix which diagonally partitions $\mathbf{Z}$ at $(T_1, T_2, ...T_m)$, i.e. $\overline{\mathbf{Z}} = diag(\mathbf{Z_1}, \mathbf{Z_2}, ..., \mathbf{Z_m})$.

By minimizing the sum of squared residuals based on the least squares principle, we obtain the break point estimators as global minimum of the objective function. Since testing for multiple breaks may generate a significant computational burden, Bai and Perron use an algorithm based on the principle of dynamic programming. They also provide several ways to test and confirm the number of breaks and discuss how to construct confidence intervals. In our estimation, since the series we use are nonstationary, most of the test statistics proposed in Bai and Perron's original paper are not available. However, Bai and Perron's technique can provide a consistent estimation of the number and timing of possible breaks and thus the technique provides useful information to our study here.

4 Data description and preliminary tests

We collect data from the Taiwan Economic Journal Asia Emerging Market Data Base. In order to have similar underlying features for study of the A and B share markets, we construct our own indices. Thirty stocks (See Table .1 in the appendix for a full list of chosen stocks) are selected from the Shanghai Stock Exchange, for companies that have both A and B shares issued over the full sample period. We construct monthly equal valued and value weighted indices. The full sample period is monthly, from January 1995 to April 2005, giving 124 observations. The indices use January 1995 as base date. Note that although the price reflects the different currency denomination, whereas the B share is denominated in US dollars, we do not explicitly include this into our data analysis. The reason is that due to foreign exchange policy in China over our data period, the exchange rate between US dollars and RMB Yuan is reasonably stable.

We present graphs of the two indices in figures 1 and 2 below. Note that we are using indices and not prices. Direct observations from these diagrams of equal weighted and value weighted indices indicate that they are not likely to exhibit a long run relation over the full sample. Instead it may be inferred that there are two possible breakpoints around the 30th (June 1997) and 75th (March 1991) observation.

Figure 1. **Equal Weighted Indices**

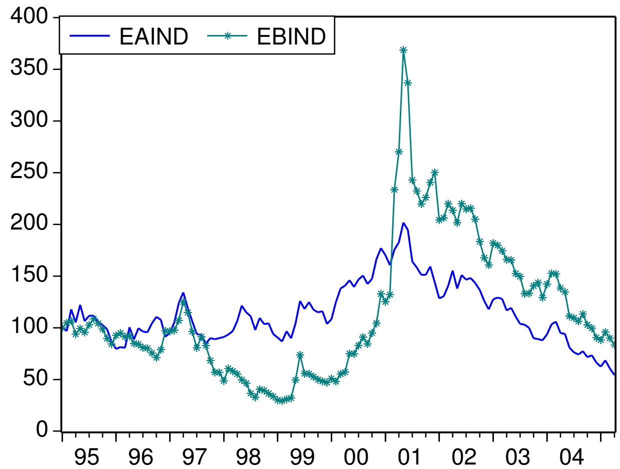
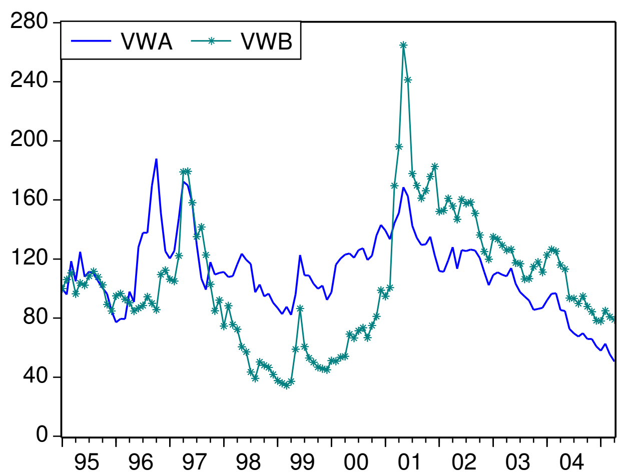


Figure 2. **Value Weighted Indices**



Descriptive statistics in Table 2 shows that value weighted indices have lower volatility than equal weighted indices indicating that the smaller capitalised stocks are more volatile, and also A indices have lower volatility. All of the indices have positive skewness during full sample period. ADF and PP Unit root tests, reported in Table 3, suggest nonstationarity for all of the price indices; we can perform cointegration tests on the indices.

Table 2
Descriptive statistics(EW: Equally Weighted; VW: Value Weighted)

Item	EWA index	EWB index	VWA index	VWB index
Mean	113.8867	115.1453	110.4417	103.6505
Median	106.4746	96.74705	109.8023	97.73975
Maximum	201.6682	368.579	187.9837	264.8024
Minimum	4.3308	29.3476	50.6033	34.448
Std. Dev.	29.15287	65.76468	25.90454	42.8546
Skewness	0.626471	1.206933	0.253819	0.807526
Kurtosis	3.11473	4.502971	3.329231	4.07038
Jarque-Bera	8.178966	41.77597	1.891462	19.39622
Number of observations	124	124	124	124

Table 3
Results of Unit root tests

	ADF		PP	
	Level	First Difference	Level	First Difference
EW A Index	-1.32253	-10.8731***	-1.20715	-10.9945***
EW B Index	-1.98978	-8.76536***	-1.72687	-8.5446***
VW A Index	-2.39884	-9.70088***	-1.91366	-10.0178***
VW B Index	-2.48613	-8.91876***	-2.16172	-8.7166***

*Note: ** represents significant at 5% level, *** represents significant at 1% level. Critical values are given by MacKinnon (1996).*

5 Empirical results

5.1 Standard Cointegration test

We perform standard cointegration tests using both residual based cointegration test results and the Johansen procedure. None of these tests are significant in rejecting the null of no cointegration (see Table 4). The results are just a confirmation of what we observed in figures **??** and **??**. This suggests that our assumptions that lead to the existence of cointegration are not consistent with the data we are using. In other words, the Chinese market is segmented such that different expectations and discount rates are driving the indices on different time paths or that the market prices are not consistent with the fundamental value and driven by behavioural factors which differ across markets.

5.2 Residual based Cointegration test with structural break

We now consider the possibility of structural breaks within the full sample period. We have already identified two possible dates and the potential forces which are driving them. One of the major changes would be 28th of February 2001, when the Chinese government allowed domestic investors to trade on

Table 4
Standard cointegration test results

Panel A	Residual based test		
	Deterministic trend	ADF	PP
	Intercept	-0.98555	-1.08813
Equal weighted	Intercept and trend	-1.63386	-1.72839
	None	-0.99218	-1.09478
	Intercept	-1.59285	-1.59285
Value weighted	Intercept and trend	-1.92238	-1.92238
	None	-1.60023	-1.60023
Panel B	Johansen test		
	Number of CE	Max-eigenvalue	Trace statistics
Equal weighted	None	5.988237	9.161201
	At most 1	3.172964	3.172964
Value weighted	None	4.847163	7.861862
	At most 1	3.014699	3.014699

Note: Critical values for residual based cointegration test are nonstandard critical values for ADF and PP tests.

the B share market. The second significant event over our data period was the Asian financial crisis in 1997 especially impacting, we would expect, on the B share market.

Technically, if structural changes are ignored when they are indeed present, the standard cointegration tests are biased. To consider this potential problem of standard cointegration analysis, we first look at Gregory and Hansen test with possible one break in the cointegrating relation. Test results are presented in Table 5 and in the Figures 3 and 4[2].

Table 5
Gregory and Hansen test results for full sample

		EW Indices		VW Indices	
	Model type	Test statistics	Break date	Test statistics	Break date
	CC	-2.6261	2000.12	-3.31988	2001.07
ADF	CT	-4.39566	2000.11	-4.40506	2000.11
	CS	-2.8638	2000.12	-3.3126	2000.11
	CC	-12.6031	2000.12	-17.6733	2001.06
Z_a	CT	-32.7209	2000.12	-34.9486	2000.12
	CS	-14.8444	2000.12	-18.606	2001.06
	CC	-2.67211	2000.12	-3.07708	2001.06
Z_t	CT	-4.2783	2000.12	-4.39286	2000.12
	CS	-2.88845	2000.12	-3.19886	2001.06

*Note: we obtain critical values from Gregory and Hansen (1996) Table 1. For significant level 1%, we give a ***, level 5% with ** and 10% a *.*

[2] Only Z_α statistics are plotted in these figures for equal weighted indices and value weighted indices. The ADF and Z_t test statistics have similar patterns which are available upon request.

None of the tests reported in Table 5 provide significant evidence in favour of a cointegrating relation. The reason for this situation might be explained by the graphs. In each and every case, we observe two local minimums instead of one, which suggest that we should look at estimating for more than one break.

Figure 3. Z_a **statistics for the model of CC, CT and CS: Equal weighted indices**

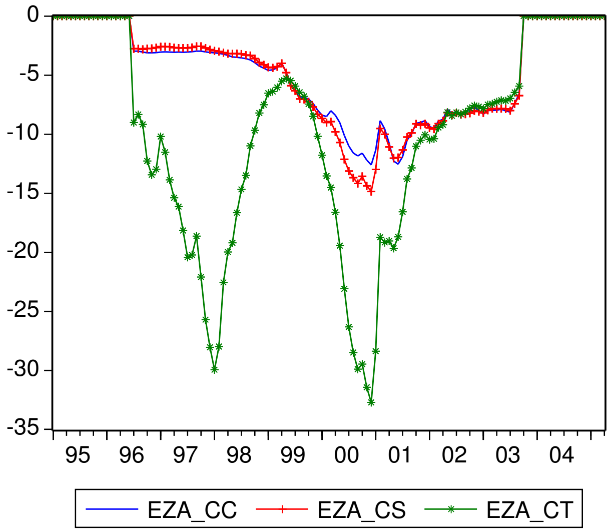
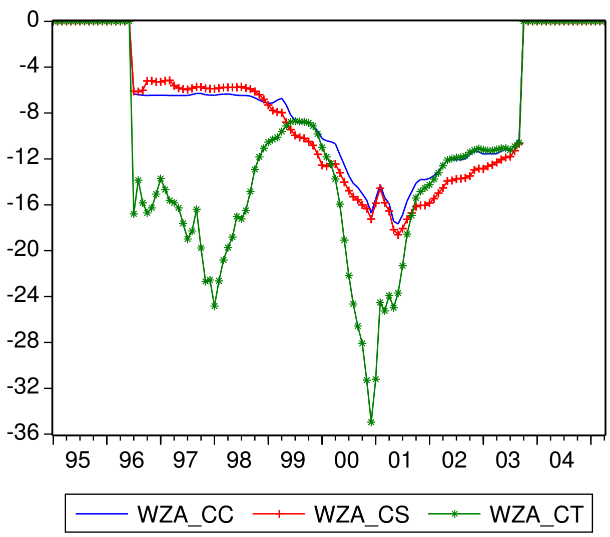


Figure 4. Z_a **statistics for the model of CC, CT and CS: Value weighted indices**



5.3 Test on Multiple breaks

Gregory and Hansen tests provide the possibility of identifying one break only in the whole sample period, however, there are potential cases of more than one break. We now exploit this situation using Bai and Perron (1998, 2003) (BP thereafter). In BP, they consider a linear regression and identify date and number of breaks using two criteria: SSR (Sum of Squared Residuals) and Information criteria. As mentioned in BP, these criteria are consistent even the series are nonstationary. BP's model allow us to consider partial structural break as well as full structural break. We consider only mean shifts in a linear regression between A and B indices, where we allow maximum 5 breaks and consider a standard trimming value of 0.15. Using information criteria (see BP for details), we conclude that two breaks are preferred. We observe the break dates to be at the start of 1998 and 2001 for both equal and value weighted indices, see Table 6 and Table 7.

Table 6
Multiple breaks test for Equal weighted indices

No. of Breaks	SSR	Break point	BIC	LWZ
0	31.40099	N/A	-1.3734	-1.3653
1	11.4016	2001.02	-2.3088	-2.2309
2	3.2497	1998.01 2001.02	-3.4862	-3.3383*
3	2.9899	1998.01 2001.02 2003.09	-3.4918	-3.2735
4	2.6848	1996.06 1998.03 2001.02 2003.09	-3.5217	-3.2328
5	2.4706	1996.06 1998.02 1999.08 2001.02 2003.09	-3.5271*	-3.1672

*Note: Optimum SSR selected on information criteria are shown with a *; LWZ is the modified BIC criteria, see Bai and Perron (1998) for detailed explanation*

5.4 Sub-sample evaluation

We now proceed to consider sub-sample properties based on the methodology of Gregory and Hansen (1996). Two sub-samples are considered: January 1995 to January 2001 and March 1998 to April 2005 with sample size of 73 and 86 respectively. The first one covers Asian financial crisis but excludes the period following regulatory changes, and the second one excluding the crisis but including policy innovation.

Since the sample size is relatively small, we do not use the asymptotic critical values provided by Gregory and Hansen (1996). We calculate exact critical

Table 7
Multiple breaks test for Value weighted indices

No. of Breaks	SSR	Break point	BIC	LWZ
0	19.67168	N/A	-1.8411	-1.833
1	8.9456	2001.02	-2.5514	-2.4735
2	3.2227	1998.03 2001.02	-3.4946*	-3.3466*
3	3.0031	1996.06 1998.03 2001.02	-3.4874	-3.2691
4	2.9639	1996.06 1998.03 2001.02 2003.09	-3.4228	-3.1339
5	2.949	1996.06 1998.02 1999.08 2001.02 2003.09	-3.3501	-2.9902

*Note: Optimum SSR selected on information criteria are shown with a **

values with a Monte Carlo simulation similar to the one they adopt based on response surface to solve this problem. The results of our sub-sample tests are presented in table 8. It is clear that for the second sub-sample, there is consistent and significant evidence that the A and B share indices are cointegrated with one single break at February 2001. The break point is consistent with the timing of the regulatory change. Further diagrammatic evidence to support this conclusion is provided in the appendix. On the other hand, the evidence from first sub-sample test is not that conclusive. Some test statistics are not significant; some are only marginally be able to reject the null of no cointegration against the alternative of cointegration with a single break.

5.5 Cointegration test with dummy variables

We now consider the identification of cointegration using dummy variable to control for the break dates. This means that we do not have to split the sample which gives us a larger sample size. We construct two dummy variables $D_1 = I(n \geq 39)$[3] and $D_2 = I(n \geq 74)$. Thus our dummies correspond to the date of March 1998 and February 2001. It is worth to note that including two dummy variables in the system might affect the distribution and critical values in cointegration test. We construct exact critical values with Monte Carlo simulation, where two dummy variables are considered. Table 9 provide

[3] $I(\cdot)$ is the identification function which equals unity if the argument is true and zero otherwise.

Table 8
Gregory and Hansen test results for sub-samples

		Panel A	**Sample I**		
		EW Indices		VW Indices	
	Model type	Test statistics	Break point	Test statistics	Break point
	CC	-4.83962*	1998:02	-4.27211	1998:01
ADF	CT	-4.74469	1998:02	-4.50921	1998:01
	CS	-5.72678*	1998:01	-4.97725	1998:03
	CC	-34.6539*	1998:01	-25.9374	1998:01
Z_a	CT	-34.0865	1998:01	-27.4172	1998:01
	CS	-40.5427**	1998:01	-32.3964	1998:01
	CC	-4.53622*	1998:01	-3.75177	1998:01
Z_t	CT	-4.47239	1998:01	-3.90581	1998:01
	CS	-5.06478*	1998:01	-4.42923	1998:01
		Panel B	**Sample II**		
		EW Indices		VW Indices	
	Model type	Test statistics	Break point	Test statistics	Break point
	CC	-5.42337**	2001:02	-6.27126***	2001:02
ADF	CT	-6.36525***	2001:02	-6.15276***	2001:02
	CS	-7.06112***	2001:02	-6.27633***	2001:02
	CC	-43.3553**	2001:01	-48.1196***	2001:02
Z_a	CT	-47.5665**	2001:02	-47.0772**	2001:02
	CS	-56.5921***	2001:02	-53.2042***	2001:02
	CC	-5.28933**	2001:01	-5.75882***	2001:02
Z_t	CT	-6.40302***	2001:02	-5.91025***	2001:02
	CS	-7.10722***	2001:02	-6.27584***	2001:02

*Critical values are calculated through a simple Monte Carlo simulation with 10000 experiments. We identify a significance level of 1% with a ***, level 5% with ** and 10% with a *.*

all test statistics. In all three situations considered we significantly reject the null of no cointegration.

A further confirmation is made by the Johansen type test, where we include the two dummy variables as exogenous regressors in the VAR. Both maximum eigenvalues and trace statistics are significantly reject the null or no cointegration in favour of one cointegration relationship.

5.6 Equilibrium Correction Model (ECM) representation

In this subsection, we use the two-step cointegration analysis procedure proposed by Engle and Granger (1987) to estimate an ECM equation for the A and the B share index. Firstly we considered both A and B shares equation and found that the A share index does not adjust to the equilibrium error. Hence we treat the A share index as exogenous and enter it directly into the B share index equation. This also implies that the cointegrating equation repre-

Table 9

Residual based cointegration test with dummy variables

ADF statistics	T1	T2	T3
Equal weighted	-5.73817***	-5.90544***	-7.19458***
Value weighted	-5.45765***	-5.45619***	-5.73564***

Note: 1. We perform cointegration test for three alternatives: T1 represents break in the intercept without time trend, T2 represents break in the intercept with time trend and T3 represents break in the intercept as well as cointegrating relationship. Critical values are calculated with 50000 experiments for out sample size and dummy variables.;
2. For T1, critical values are: -4.89 -4.27 -3.97 for 1%, 5% and 10% respectively. For T2, critical values are: -5.25 -4.62 -4.30 or 1%, 5% and 10% respectively. For T3, critical values are: -5.59 -4.92 -4.58 for 1%, 5% and 10% respectively.;
3. The ADF statistics are performed to OLS residuals with only intercept considered. Optimal lag order for the tests is selected with the help of BIC

Table 10

Johansen test with dummy variables as exogenous variables

	Number of CE	Max-eigenvalue	Trace statistics
Equal weighted	None	29.29809***	30.12533***
	At most 1	0.827233	0.827233
Value weighted	None	34.60031***	38.07972***
	At most 1	3.479413	3.479413

*Note: For significant level 1%, we give a ***, level 5% with ** and 10% a *. For Johansen test, we consider a structural break in constant only for T1 (Breaks in the intercept without trend), which means there are two intercept shift at associated break points.*

sents the determination of the B share index. Equations 18 and 19 present the results for the ECM for the equal weighted B share index, whereas Equations 20 and 21 present results for the value weighted B share index. Note that the ECM term contains two dummy variables defined in subsection 4.5 and we consider a shift in intercept only. In specifying the ECM we include two dummy variables to reflect unusually large positive and negative movements in returns. In the estimated equations, numbers in parentheses below coefficient values are t-statistics. The diagnostic tests include the normality test is Jacque-Berra, the serial correlation is the F-test with two lags, the ARCH test is an LM type test with one lag and finally the heteroscedasticity test is an F-test. The p-values for each test are shown in the brackets.

$$ECM_t = y_t + 0.88 + 0.69dum1 - 1.16dum2 - 1.16x_t \tag{18}$$

$$\Delta y_t = \underset{(8.26)}{0.76\Delta x_t} + \underset{(2.25)}{0.14\Delta y_{t-1}} - \underset{(-3.91)}{0.18ECM_{t-1}} + \underset{(4.75)}{0.28dum3} + \underset{(5.75)}{0.25dum4} \tag{19}$$

Diagnostic tests: R-squared 0.58; Adjusted R-squared 0.57; AIC = -2.0588; SBIC = -1.9439 Normality = 4.96 (0.084); Serial correlation = 1.05 (0.36);

ARCH = 0.86(0.36); Hetero = 1.49 (0.17)

$$ECM_t = y_t - 0.64 + 0.57dum1 - 0.89dum2 - 0.84x_t \tag{20}$$

$$\Delta y_t = \underset{(3.32)}{0.33\Delta x_t} + \underset{(2.70)}{0.14\Delta y_{t-1}} - \underset{(-4.25)}{0.27ECM_{t-1}} + \underset{(10.97)}{0.30dum3} - \underset{(-16.42)}{0.25dum4} \tag{21}$$

Diagnostic tests: R-squared 0.67; Adjusted R-squared 0.66; AIC = -2.2291; SBIC = -1.8827 Normality = 2.55 (0.28); Serial correlation = 0.33 (0.72); ARCH = 0.62 (0.44); Hetero = 3.71 (0.00)

Considering first the long-run relationship, the notable issue is that the response of the B share equal weighted index to changes in the equivalent A share index is greater than unity. Hence the B share discount will fall in a rising market and rise in a declining market. This observation suggests that interpreting the effects of the 2001 policy change requires knowledge of the state of the market. It has been suggested that the discount reduced significantly after the regulatory change but has since moved back to levels associated with pre-2001. During this period we have seen a falling stock market which is consistent with the discount increasing. Thus the initial effects of the regulatory change are outweighed by the short run effects of a falling stock market. Note also the opposite effect for the value weighted index. The impact for the equal weighted index must be driven by low capitalisation stocks firms as observed Karolyi and Li (2003) who also observed that discounts seem to fall most for momentum stocks, also consistent with the response of greater than unity on the short run change in A shares when we use the equal weighted index. We may also note that the impact of the dummy variables for the two structural breaks are consistent with our interpretation of these events.

In the ECM models reported above we have included more dummy variables to account for potential outlier observations. This relates particularly to the dates around the change in regulation and also times when stock index changes are unusually large (mainly associated with the Asian Crisis period). The dates corresponding to the dummies reported are: dum3 (February and March 2001), dum4 (December 1996, May 1999, May 2000, May 2001), dum5 (April 1997, May and June 1999, December 2000, March and May 2001), dum6 (January, March and July 1998, July 1999).

If we consider each of the equations above we obtain further insight into the behaviour of A and B share markets. For the equal-weighted index we observe that the speed of adjustment to the equilibrium error is rather low at 0.18, although since we are looking at monthly data it suggests around 6 months for the B index to adjust to its long-run value. Looking at the value weighted index we can see a faster speed of adjustment with less than 4 months being the duration of adjustment. The interest in this comparison is that it suggests that low capitalized stocks adjust more slowly and these have a disproportionate effect on the equal weighted index.

6 Discussions and Conclusion

6.1 Discussion of the results

We have presented a series of results which indicate that, despite the existence of significant price differences across A and B shares, when we take into consideration the influence of structural changes, the share markets appear to move together. The long-run relationship identifies the B share discount and that it is related to the share indices in a predictable manner. We now consider the implications of this result for understanding the cause of the discount.

First we note that there are specific events which are associated with the structural breaks. Using the results of section 4.6 we may observe that the Asian Financial Crisis has positive effects on the B share discount. This is consistent with both of our explanations for the B share discount. The impact of the financial crisis will have been to increase the risk premium international investors required in order to hold Chinese shares. The effect of the regulatory change is negative for the discount. This would suggest that the effect of allowing Chinese residents to trade B shares was to reduce the risk premium that was applied and hence the price of B shares moved towards those of the A shares. Note that the effects of the latter change are much larger than for the value weighted index which is consistent with the observation that the adjustment fell mainly on small firms' stock (see Chen et al. (2001)). Secondly we may note the moderate speed of adjustment of the discount to its long-run equilibrium value which suggests that it takes a relatively long time for the discount to return to its equilibrium value.

The role of the Asian financial crisis is consistent with increases in the discount rate as international investors increase the risk premium and revise downwards forecasts of future dividend growth. Note that both A and B shares are affected by the crisis in a downward direction. However for the A shares the effects were much less persistent which makes it difficult to explain the response of Chinese investors to adjustment of fundamental dividend flows if we also suppose that B share markets were driven by fundamentals. Short run increase in the risk premium seems to be the reason for the A share adjustment. Beyond the Asian crisis the indices move together (and hence the B share discount is relatively stable) and the B share equal weighted index has returned to its pre-crisis level. The fundamental explanation for this must be based on the reduction in risk premium and expected dividend growth. Once Chinese investors are allowed into the B market we observe a very significant spike in the B share index. However this does not completely remove the B share discount and over the remaining period the B share index is declining against the A share index in a falling market. From a fundamental perspective we may observe that introducing Chinese investors into the A share market will generate a lower risk premium if they judge the risks to be lower or they have lower risk aversion (as in Eun et al. (2001)). However a puzzle is the increase in the discount after the initial adjustment to the policy change. As we have discussed above some authors have argued that this implies an explanation more firmly founded in the behavioural finance tradition.

The noise trader model we introduced in section 2 provided this sort of foundation. We showed there that changes in a number of behavioural factors could be used to explain why the cointegrating relationship would change. We may infer that the structural break in the relationship around the time of the Asian Financial Crisis is driven by such factors as a relative (B to A market) decline in noise trader sentiment (as measured by the δ_A^*, δ_B^*), by an increase in relative risk (σ_A^2,σ_B^2), by a relative increase (decrease) in pessimistic (optimistic) noise traders. It seems unlikely that the regulatory change would influence expectations of noise traders but it is reasonable to conclude that the A share market is priced more highly because the noise trader sentiment is more positive than in the B market. Hence an increase in optimistic noise trader will reduce the discount (smart traders might expect an increase in B share prices and hence buy into the market as well). The fact that the discount adjusts back may well reflect the decline in sentiment post-2001 and a reduction in the number of noise traders operating in the B share market and consequent downward price adjustment.

6.2 Concluding remarks

We have analyzed the relationship between Shanghai Stock Exchange A and B share price indices in this paper. Extending from a standard cointegration framework, we allow for structural breaks during the full sample period. In our full sample period, two major events happened: the Asian financial crisis and opening up of the B share market to domestic investors. They are roughly consistent with the results we obtain from our formal testing of break dates.

After dating the break points, we conduct a standard cointegration test with two dummy variables, using Monte Carlo simulation to find exact critical value for our test. All tests conducted suggest the existence of a long run relationship between A and B share indices when we allow for two breaks.

We provide two competing explanations for our results, one based on the

Rational Valuation Formula the other using ideas from Behavioural Finance. However we are unable to evaluate fully which of these explanations is more appropriate. Investigation at the level of the individual share prices may throw more light on the issue.

However, as it stands we have been able to identify that the B-share discount is to some extent predictable and to provide evidence that it changes in response to specific shocks. We have also identified that the discount is dependent on whether the A market is rising or falling.

Appendix: list of selected stocks

Table .1
List of selected stocks

Name of the stock	A share Code	B share Code
Auto instrument	600848	900928
Baosight software	600845	900926
China Textile	600610	900906
Chlor-Alkali chemical	600618	900908
Dajiang	600695	900919
Daying	600844	900921
Dazhong Transportation	600611	900903
Erfangji	600604	900902
First pencil	600612	900905
Friendship	600827	900923
Haixin	600851	900917
Highly	600619	900910
Huaxin Cement	600801	900933
Jinjiang Investment	600650	900914
Jinqiao	600639	900911
Lianhua fibre	600617	900913
Lujiazui	600663	900932
Material Trading centre	600822	900927
Phoenix	600679	900916
SH. Sanmao	600689	900922
Sanjiu Development	600614	900907
Shanggong	600643	900924
Shanghai Diesel	600641	900920
SH Electric applicances	600835	900925
Shanghai forever	600618	900915
SH. Posts Telecoms	600680	900930
SVA electron	600602	900938
Tyre Rubber	600623	900909
Wingsung Data	600613	900904
Yaohua Pilkington Glass	600819	900918

Data source: Taiwan Economic Journal Asia Emerging Market Data Base.

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